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EARLY GROWTH AND DEVELOPMENT OF FOUR PINE SPECIES IN HAWAII

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ABSTRACT: Diameters, height, percent of stem in live crown, and survival of 9-year-old *Pinus caribaea, P. elliottii, P. radiata,* and *P. taeda* at spacings of 6 by 6 and 8 by 8 feet were measured in a plantation on Maui. The slash and loblolly pines have grown about twice as fast as in the southern United States. Growth of the Monterey pine is similar to that in New Zealand, Australia, and South Africa. Caribbean pine has poor form. None of the four species has shown much self-pruning.

RETRIEVAL TERMS: Pinus caribaea; Pinus elliottii; Pinus radiata; Pinus taeda; Hawaii; species trial; plantation spacing; growth response.

OXFORD: (969):232.11[-174.7 *P. caribaea* + 174.7 *P. elliottii* + 174.7 *P. radiata* + 174.7 *P. taeda*].

Hawaii has no native conifers, and few indigenous hardwood species of commercial potential. Annually it imports about 100 million board feet of lumber. Of this volume, more than 90 percent is softwood. Obviously, it would be to the State's economic advantage to grow some of this timber locally—if it can be done at reasonable costs.

More than 45 species of pine have been experimentally planted in Hawaii during the past 100 years. Most of the plantings have been small. Many have failed, but some have done well on certain sites. Only a few measurements of growth under stand conditions have been published. Bryan[1] and Carlson and Bryan[2] compared the relative success of several pine species. In a second paper, Carlson and Bryan[3] reported 81 percent survival in 4-year-old loblolly pines that averaged 5 feet tall, in a 1-acre plot of 83 trees. Growth and survival of 5- and 6-year-old pines in the Waiakea Arboretum in Hilo were measured by Richmond,[4] Carpenter and Richmond,[5] and Carpenter.[6] They rated only one 3-tree plot of Caribbean pine as "very good" in general condition and appearance. It had 100 percent survival at age 6, and averaged 35 feet tall and 6.5 inches d.b.h. Skolmen[7] sampled the specific gravity of 12 pine species at a number of locations throughout the islands. His data included height and d.b.h. of the 1 to 10 trees sampled at each spot. Ages varied from 12 to 52 years.

We measured trees in a 9-year-old, 2-acre spacing experiment at Olinda on the island of Maui. Four pine species had been planted there in October and November 1958: Caribbean pine (*Pinus caribaea* Morelet), slash pine (*P. elliottii* Engelm.), Monterey pine (*P. radiata* D. Don), and loblolly pine (*P. taeda* L.). Our measurements suggest that the Caribbean pine cannot be considered a success on this site

because of its poor stem form. The seed may have been obtained from lowland trees not adapted to this elevation. Growth of the other three species appears promising.

Plantation Design

The plantation is at 3,700 feet elevation. Aspect is north, with a 25 percent slope. Annual rainfall averages 54 inches, with more than 2 inches normally falling in all months except June and September. Annual temperature averages 57°F.; frost occurs occasionally during winter. The soil is Olinda loam,[8] which is typically more than 40 inches deep and practically free of stones.

The area was used for grazing and agriculture starting in the 1800's, but was abandoned in 1940. The pines we measured were planted in eight adjoining square 1/4-acre blocks. Each of the four pine species was planted in two of the blocks. Spacing was 6- by 6-feet in one block and 8- by 8-feet in the other. Caribbean pine seed was obtained from Honduras through the U.S. Department of Agriculture's Beltsville Research Center in Maryland; seed of the other three species was obtained commercially. The seedlings were raised in the Olinda nursery. They were planted as 1-0 stock, not pruned, or graded for size. Tops ranged from 10 to 18 inches and roots from 6 to 10 inches long. Failures were replaced in December 1958, and the seedlings were weeded in January 1959.

In August 1967, each block was divided into four parts for sampling purposes. We measured d.b.h. on a 25-tree plot centered in each of the four parts, and the height of five trees selected randomly from the 25 *(table 1).*

Results and Discussion

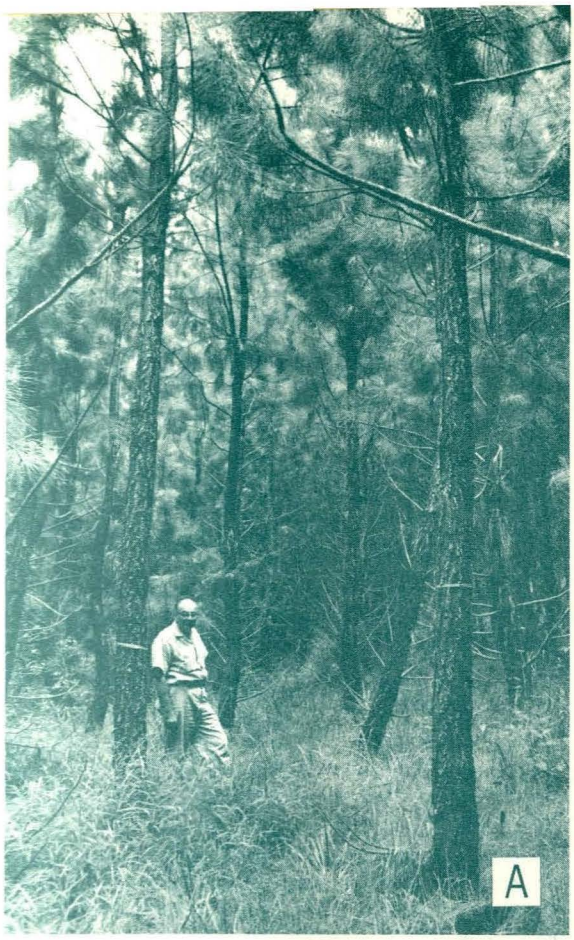
None of the four species has shown any appreciable amount of self-pruning *(fig. 1).* The Caribbean pine has very poor form in both spacings, with many deformed stems. The canopy is still open. Ground cover consists of dense grass with patches of gorse (*Ulex europaeus* L.) and blackberry (*Rubus penetrans* Bailey). The slash pine has good form, and the crowns have closed. The ground in the 6- by 6-foot spacing is covered mainly by litter. Grass and patches of blackberry are present in the 8- by 8-foot spacing. The Monterey pine has variable form, with the somewhat crooked stems and swollen nodes which characterize young trees of this species. Some trees have been bent or broken by wind. Their crowns have closed, and the ground cover consists mostly of grass. The loblolly pine has good form and a dense canopy. Litter and a few patches of blackberry cover the ground.

Height and diameter growth of the Monterey pine is similar to that of average stands in New Zealand, Australia, and South Africa.[9] Growth of the slash and loblolly pines approximates that of stands about twice as old on average sites in the southern United States.[10,11,12]

Skolmen[7] found that the specific gravity of Hawaii-grown slash and loblolly pine wood was lower than that of these species in the South. This may mean that the wood produced in Hawaii will be unsuitable for structural use. Specific gravity of Hawaii-grown Monterey pine wood, on the other hand, was equal to that of this species in Australia and New Zealand.[7] Pruning of all species will be necessary to produce clear wood on the short rotations made possible by the rapid growth rates.

Table 1.--*Average diameter, height, and survival of 9-year-old pines at Olinda, Maui, Hawaii*

Species and spacing (ft.)	D.b.h.	Total height	Stem in live crown	Survival
	Inches	*Feet*	*---Percent---*	
Caribbean pine:				
6 by 6	6.5	32	62	93
8 by 8	6.7	31	68	98
Slash pine:				
6 by 6	5.6	31	65	97
8 by 8	6.9	34	68	100
Monterey pine:				
6 by 6	4.8	57	60	99
8 by 8	5.9	57	70	100
Loblolly pine:				
6 by 6	5.2	29	59	99
8 by 8	6.3	33	67	98



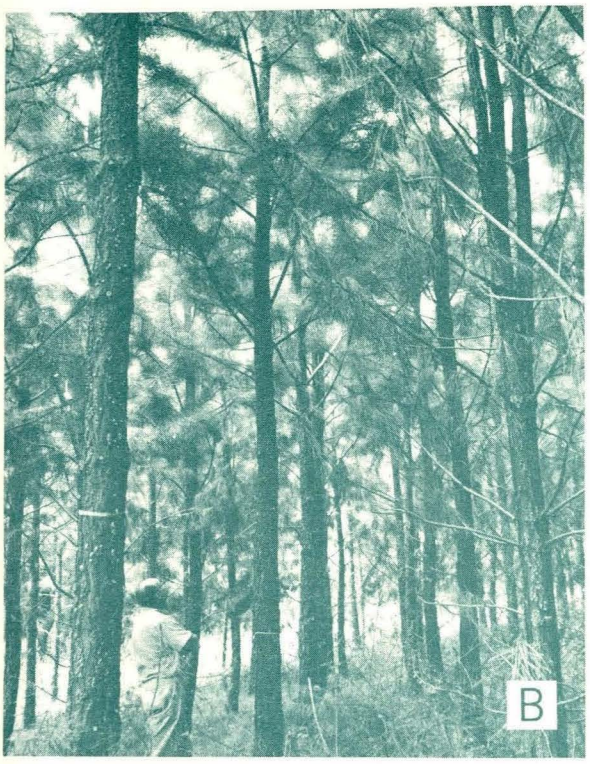
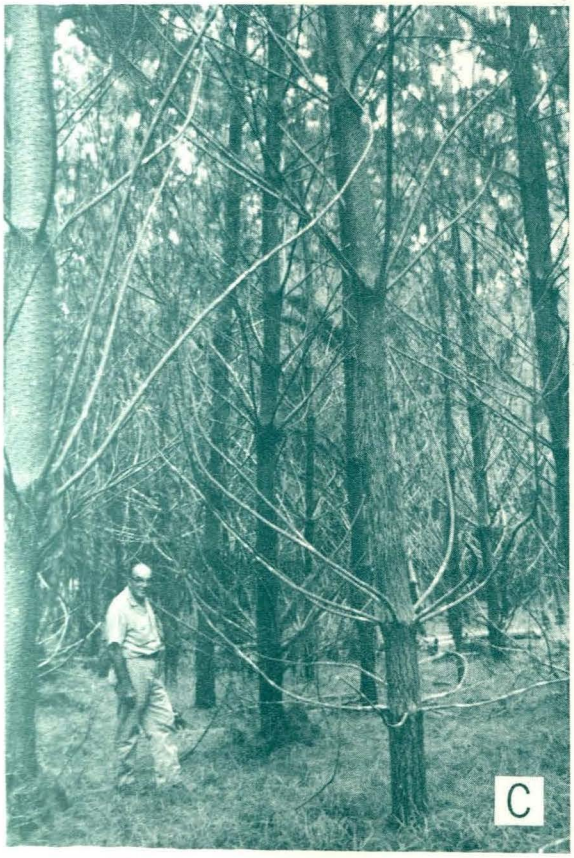
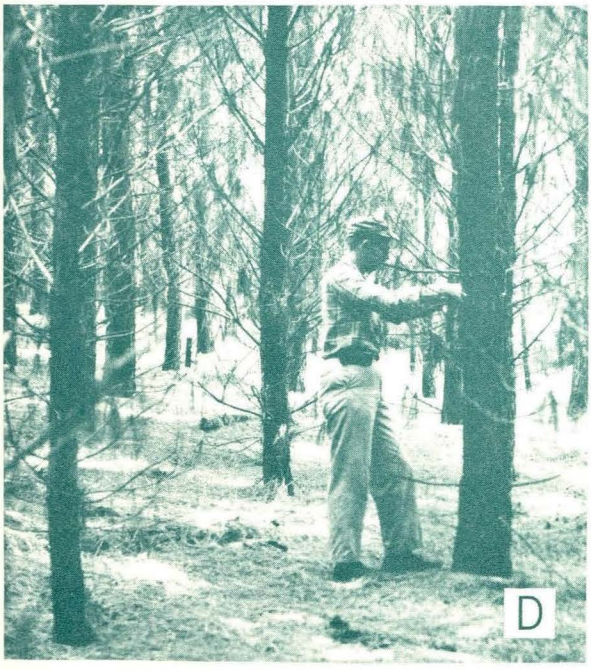


Figure 1.--*Growth of four species in 1967, when they were 9 years old, in 8- by 8-foot spacing:* A, *Caribbean pine; two banded trees in the foreground were among the few straight stems in this stand, and have been pruned;* B, *slash pine; three banded trees in the row on the left have been pruned;* C, *Monterey pine;* D, *loblolly pine.*





If the present rates of growth continue, the potential rotation age is about 30 years. However, several factors must be examined to determine which of the three promising species would be the best choice to plant on this type of site in Hawaii. The factors include the properties of the wood, the total quantity of merchantable material produced, the over-all form and quality of the stems, and the amount of damage caused by injurious agencies. This assessment cannot yet be made.

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Notes

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